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New Foundations for Survivability/Lethality/Vulnerability Analysis (SLVA)

by Michael W. Starks and Richard Flores

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Military transformation is a national goal. While top level and ambiguous descriptions have been replaced with focused vision statements, clearly specified technical parameters and metrics of the new battlefield have not been developed by the Defense community. As the Department of Defense entity devoted to survivability/lethality/vulnerability analysis (SLVA), the Survivability/Lethality Analysis Directorate of the U.S. Army Research Laboratory has pursued this issue for the past several years. In this technical note, we outline the conditions needed to develop adequate SLVA analysis parameters and metrics and then derive new SLVA practices for the Future Force.
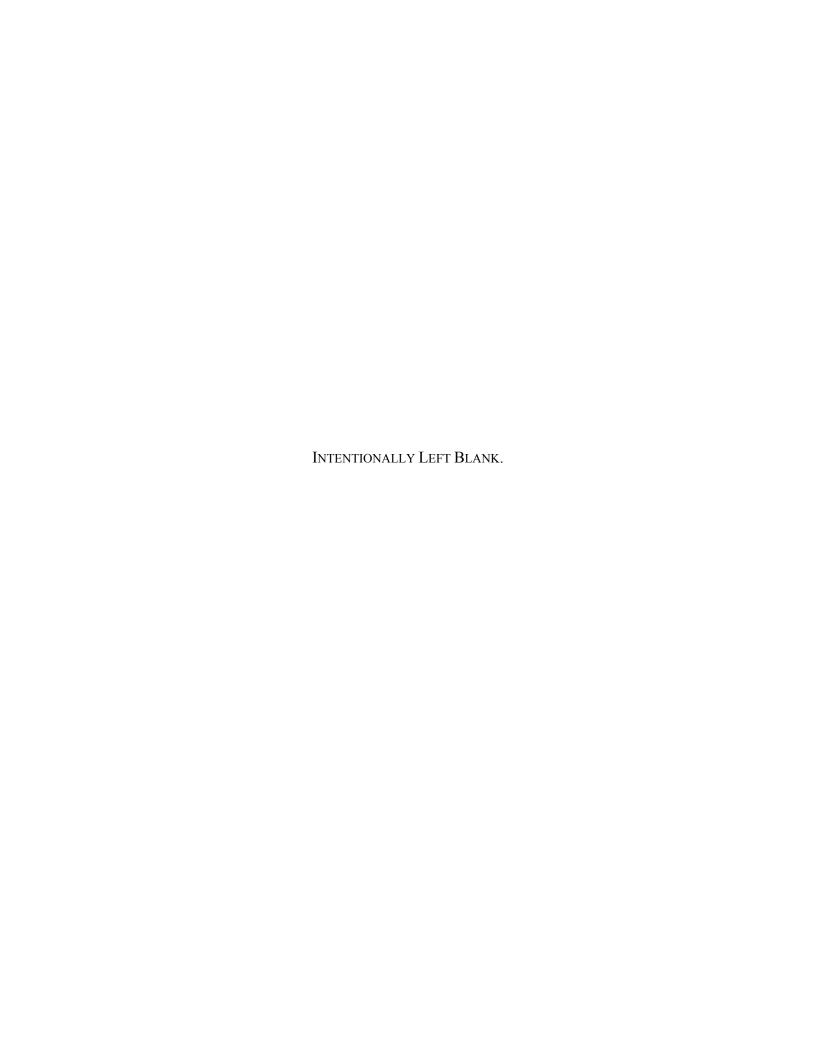
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1. Introduction

Military transformation is a national goal. While top-level and ambiguous descriptions have been replaced with focused vision statements, clearly specified technical parameters, measures of survivability and performance, and utility metrics for the new battlefield have not been developed by the Defense community. As the Department of Defense (DoD) entity devoted to survivability/lethality/vulnerability analysis (SLVA), the Survivability/Lethality Analysis Directorate (SLAD) of the U.S. Army Research Laboratory has pursued these issues for the past several years. In this technical note, we outline the conditions needed to conduct adequate survivability/lethality/vulnerability (SLV) analysis and then derive progressive SLVA practices.

Initially, we address the new foundations for SLVA needed to accurately assess the Future Force, presenting the facts, constraints, boundary conditions, and adequacy criteria that establish the need for these new foundations. Next, we briefly describe current and planned SLAD strategy and activities to support new methods of fighting.

2. Transformation

In a one-superpower world, the variability and complexity of military contingencies facing the United States has increased compared to those we faced in the 20th century. Therefore, we need a different array of military forces with different technological capabilities to match these contingencies. This process of matching 21st-century threats to needed United States capabilities is called "transformation."

The U. S. Secretary of Defense has asserted that preparing for the future will require us to think differently and develop forces and capabilities that can adapt quickly to new challenges and unexpected circumstances. An ability to adapt will be critical in a world where surprise and uncertainty are the defining characteristics of our security environment. The Secretary has frequently used the word "adapt" when discussing transformation (*1*). Although the ability to adapt is key for the Future Force, the new emphasis on adaptation raises some formidable issues for SLVA. We must identify, articulate, and actively pursue SLVA methods that can gauge how well forces are adapting to new environments.

For U.S. forces to quickly adapt, they will need appropriate and timely information available to all levels of military decision makers. Computer and communication networks lie at the core of this process. For example, the Armed Services are consciously trading mass for MIPs (millions of instructions per second). In doing so, the paramount factor influencing survivability on the battlefield shifts to information and away from improvements in weaponry or armor protection.

Thus, how information is used by decision makers on the battlefield is the key survivability question for the future. Soldiers, systems, and units will survive, or not survive, because they adapted, or failed to adapt, to new circumstances. If they adapt successfully it will be because decisions were based on correct, timely, and relevant information. This link between successful adaptation and survivability is central to 21st-century warfare and to Defense transformation.

Trading mass for MIPs is not an oversimplification, but rather a thread that appears, in detail, through numerous program documents, including the Army's Future Combat System and Future Force requirements; Organizational and Operational Plans; and Test and Evaluation Master Plans and program plans. These documents assume the mass/MIPs trade is valid; therefore, we consider this trade as legitimate U. S. Defense policy rather than as a subject for debate. In response to this policy, SLAD is developing methodologies, analytical tools, and models and simulations (M&S) to help assure that we are making the trade in the most sensible way possible.

Another example of the new battlefield dynamics can be discerned from a recent Armed Forces Journal (AFJ) article that discusses effects-based operations (*2*). Such operations are a key component of the emerging U.S. Joint Forces Command doctrine. Two of the "basic tenets" for this type of warfare are presented in the article. One tenet is to pursue "attrition only when necessary," instructing commanders to avoid "non-essential" attrition as a matter of policy. In the past, shrewd commanders have always looked for ways to induce the enemy to give up without a fight or to bypass enemy strongholds enroute to the strategic objective. Nonetheless, the guidance to avoid attrition is a radical shift in emphasis for the warfighter. Loss-exchange ratios and territorial metrics relevant to industrial age Army warfare are less relevant now.

The second tenet mentioned in the AFJ article is "people, not things." The emphasis is on leaders and soldiers as the key factors of the warfighting system; previously, the focus was almost exclusively on equipment. To be comprehensively valid, survivability analysis must consider the influences of the warfighter within the context of the system. A recent book published by the Information Assurance Technology Analysis Center, *Measuring the Effects of Network Centric Warfare* (*3*), states that to accurately assess the impact of Network-Centric Warfare, the impact of the soldier and leader must be considered. This condition is certainly not satisfied by most traditional SLVA with its materiel-centric focus.

While these representative tenets of future operations, as published in the AFJ and other professional literature, may appear commonplace, trite, or even trivial, such straightforward tenets have a major impact on the requirements for future SLVA methodology.

3. Traditional Survivability, Lethality, and Vulnerability Practice

This section explains why traditional SLVA practices and their corresponding legacy models and simulations are not adequate for the analysis of the future, information-dependent force. While current M&S does provide some valuable SLVA information about equipment, it does so abstracted from the context of the soldiers and their leaders.

The DoD acquisition process is geared to develop, test, evaluate, and purchase quantities of individual systems (such as tanks, ships, aircraft, and radios). In the past, such individual systems have been required, developed, experimented on, simulated, tested, evaluated, purchased, and operated by our military forces. Consequently, SLVA (along with most cost analysis, logistical analysis, performance analysis, etc.) has focused on individual systems only, so that the effectiveness of one military system is explicitly or implicitly assumed to be mathematically independent of the effectiveness of other systems. This assumption of independence, while never mathematically justified, has nonetheless permitted senior DOD decision makers to regard individual systems as subject to credible SLVA apart from the analysis of the other systems (*4*, *5*).

Traditionally, the DoD compares new equipment with the older equipment it is replacing. For example, the M109 would be compared with a CRUSADER, a first generation sensor with the next generation, or a Bradley with a STRYKER. For many decades DoD decision makers have used this type of side-by-side comparison to illuminate and decide SLVA issues. Questions concerning relative ballistic protection, compatibility of chemical/biological protective gear, electromagnetic pulse susceptibility, lethality versus a standard target set, or susceptibility of different sensors to electronic warfare, have all been considered to be independent of the interactions between friendly and enemy forces.

Currently, core SLV questions concerning a networked force cannot be coherently posed, let alone completely answered, within the constrained framework of comparing a single current system to a single developmental system. This is because the networked force fights as a system, not as an additive set of independent entities. Traditional individual-system comparisons are useful, but they do not place the system in the proper context of missions and means as perceived by the modern-day warfighter. The assessment of SLV issues for the Future Force inherently requires simultaneous consideration of multiple systems at spatially distributed locations. Such systems depend on a common network infrastructure that enables information flow and revision of strategies and behavior, and such systems may have both horizontal and vertical dependencies. For example, the SLV of a STRYKER at one location on the battlefield may be dependent on information from friendly sensors located hundreds of kilometers away. This dependence cannot be ignored in a credible SLVA of STRYKER, it is doctrinal hypothesis!

It follows that applying legacy SLV models on their own cannot accurately assess the survivability of the Future Force, even if the current SLV models are scientifically "perfect" for solving the single-thread problems for which they were developed in the first place. At best, such legacy SLV models can only provide part of the answer.

For the Future Force, there can be no question of whether or not the individual system SLV can be mathematically regarded as independent from the information flowing over the common network from a distant sensor, since, in reality, that system is considered to be directly dependent on the distant sensor. SLVA for such a system cannot be credibly handled by continuing to assume mathematical independence. Current SLV models are designed to assess specific aspects of survivability for individual systems, and they do this quite well. However, they were never intended to address the issue of survivability in a system-of-systems environment.

How well and to what extent our future forces can successfully adapt depends on timely, correct, and relevant information. A military commander must be able to dynamically evaluate each situation and then, as necessary, revise strategies and behavior. Thus, processes that enable revision of strategies, tactics, and behavior must be at the conceptual core of SLVA methodology for the Future Force. This assertion has a subtle but powerful consequence: SLVA is now inextricably tied to doctrine, tactics, and the impact of leadership. Some current SLV models do consider the SLV aspects of individual systems within the context of rough-order-of-magnitude doctrine and tactics. However, no closed models we are aware of have the ability to dynamically revise tactics and doctrine. And while legacy modeling and simulation can be relevant, the bottom line is the current models only provide some of the SLV answers we need. We must develop a way to assess the survivability of the system of systems within the context of adapting forces, both friendly and enemy.

4.   New Foundations for SLVA

As noted, current M&S are unable to credibly address the core SLV problems faced by the Future Force. Unfortunately, the state of our knowledge about transformation is such that neither we, nor anyone else, can sufficiently state the conditions necessary to produce intellectually adequate SLV M&S. However, it is possible to state some conditions regarding adequate SLV modeling (and some more specific boundary conditions that such conditions imply) that we have identified as necessary in order to create credible SLVA for the Future Force.

4.1   Necessary Conditions on Analytical Adequacy

The first condition is that SLV M&S must include a dynamic process for revising strategies and tactics on the battlefield, simulated in enough detail to permit near real-time revision of orders, plans, and combat drills. In the battlefield, such revisions take place based on emerging

information coming over the network. For a combat model to have intellectual credibility both opposing forces must be able to adapt—revise their tactics and decisions based on situational awareness—within the simulated combat. In other words, the events and responses within a scenario cannot be scripted in advance. Unfortunately, the vast majority of all existing force-on-force constructive simulations are scripted in advance, allowing for no real-time revisions based on situational awareness.

The second necessary condition is that SLVA for the future Army must have a multi-system or system-of-systems perspective. Information from distributed sources is essential to the survivability of the entire system, and this consideration must be included in force-level modeling. Given that the SLV of the Future Force depends, by explicit doctrine, on networked information from distributed sources and on the ability of our combat agents to adapt and revise their tactics and strategies as a function of that information, it follows that these phenomena must be credibly simulated in any model used to assess the SLV of a system of systems. This level of SLV M&S is not currently incorporated in the capability set of closed legacy force-on-force models.

A more general problem with traditional force-level models, in terms of meeting these two necessary conditions, is related to the scripting problem mentioned previously, but it is both more general and serious. Consider two problems which might, at first, seem cognitively symmetrical. Problem 1 would be to take a legacy, attrition-based, scripted force-level model and add credibly modeled leadership influences to permit adaptation by the simulated combat participants. Problem 2 would be to take agent models of combat participants based on appropriately modeled leadership processes and add the physics of attrition. Problem 2 appears to be potentially soluble and SLAD has made progress in solving it. Problem 1, on the other hand, has proven to be insoluble so far as we are aware. The scripting that exists in traditional models severely constrains the revision of strategy and tactics. The model developed in problem 2 would have no such restrictions.

A third necessary condition concerns the need for new input parameters, output performance metrics, and functional relationships to assess SLV for the new system of systems. Legacy SLV models are arguably appropriate for SLVA of individual systems; the inputs, outputs, and assumed functional relationships have been accepted as credible for the analyses of individual systems. However, to assess the SLV for systems of systems, we need to apply different inputs, outputs, and functional relationships to characterize the processes that revise strategies and behavior in such systems. The well-established individual system metrics—probability of detection, probability of kill given a hit, or probability of kill given a shot—were not easily developed, calculated, and accepted by the entire Defense community. Developing system-of-systems SLV metrics is more difficult than developing individual system metrics; therefore, developing and implementing a community-wide accepted set of new SLV metrics will take time.

Furthermore, existing system-of-systems metrics are not sufficiently robust to answer the questions regarding adaptation and revision of strategies and tactics. The traditional force exchange ratios are

of little help—the solution must include the dynamics of the information flow as the battlefield entities interact with each other.

4.2   Additional Considerations on Modeling Adequacy

As suggested, the rapid revision of tactics, strategy, and orders is essential to credible modeling of the Future Force, as is the appropriate use of networked information from distant sources. On the assumption that different battlefield entities (due to variations in training, experience, and personality) will make different revisions given identical information flows, it is clear that new variables need to be considered in our system-of-systems SLVA modeling. For example, some commanders/leaders are able to extract better situational awareness from the available data than others. This requires us to create a simulation environment which enables different entities to react uniquely based on their own inclinations and situational awareness of the environment. As the Department of the Army places more emphasis on the impact of the leader and the soldier within the context of the system, the survivability analysis community must do the same.

Finally, we must consider the appropriate level of granularity, or resolution, for our system-of-systems SLVA strategy. Choice of resolution is a critical issue in any modeling development plan. But it is even more critical for an analysis of the Future Force where we cannot yet clearly or precisely articulate the analytical questions we are trying to answer, the specific system-of-systems hardware results we are considering, or the details of the network architecture we need to enable the Future Force. How much detail is required in network modeling to ensure a credible approach for answering analytical questions regarding transformation? We assert that the Defense community does not yet have a definitive answer to this question.

5.   Summary of the Adequacy Arguments

One of the principal purposes of this technical note has been to articulate several of the conditions and constraints needed in developing an intellectually adequate SLVA for the Future Force. While understanding and acceptance is sought, we still believe progress has been made, even if the conditions have only been understood but not accepted. A well-rounded debate would advance the Army's understanding of what would be adequate SLVA for the Future Force, and such a debate would assist in shaping the evolving strategies used by institutions with relevant responsibilities in system and system-of-system M&S. Also, in such debates, individuals rejecting one or more of the conditions would be able to argue against the suggested adequacy criteria or on behalf of their own criteria.

The remainder of this technical note discusses the SLAD's SLVA strategy for the Future Force and how we have implemented it so far. We are considering various arguments, responses, and

potential strategies that strive to answer the question: What is the most appropriate strategy for SLAD to follow in view of the arguments presented?

5.1 Rejected "Responses" to the Adequacy Arguments

First, we describe two technical solutions that were considered and dismissed because they violated one or more of the qualifying criteria outlined above.

One current school of thought links together simulations of various classes of individual system models in order to solve analytical problems relating to a system-of-systems. At first this might appear to be a pragmatic solution to the problem; however, none of the linked simulations possess adaptation/processes to revise strategies and behavior at their core. Therefore, this additive approach does not result in a credible technical solution to the analytical problem posed in this technical note. It is critical that any proposed solution has at its core the ability to adapt or revise strategies and behavior dynamically within the simulation.

Another possible solution links relevant SLVA legacy models to a force-on-force simulation. This option may provide the best quality technical solution from a hardware-assessment point of view. However, closed force-on-force simulations suffer from similar limitations as the legacy SLVA models. Such legacy models currently use scripted combatant behavior, which does not allow for dynamic adaptation based on situational awareness criteria. An "open" force-on-force model with humans in the loop could, in principle, allow humans to provide the dynamics concerning adaptation and revision. Unfortunately, humans in the loop yield results that are non-repeatable and, moreover, are driven by the players' variable learning rates as well as by human "cheating."

5.2 SLAD Strategy for Support of Transformation

As the Army's SLVA organization, SLAD's mission and responsibility is to develop the methodologies, tools, models, and simulations that will be used to conduct SLVA of the Future Force. For several years, SLAD has been developing a new SLVA strategy for transformation. Of course, the strategy continues to evolve and become more focused as the DoD's transformation plans become more definitive.

The SLAD transformation strategy includes near-term, mid-term, and long-term components. The near-term "acceptable" SLVA of the systems-of-systems problem can be conducted by integrating SLVA data and/or legacy models with force-on-force data and/or simulations. Most of the Army community is currently engaged in some version of this approach, and several SLAD activities support this technical approach. One effort integrates SLVA data from legacy models and analytical techniques with the TRADOC (Training & Doctrine Command) Analysis Command's Combined Arms Support Task Force Evaluation Model (CASTFOREM). A related mid-term effort uses the Vulnerability/Lethality server to address the problem of directly linking ballistic models to CASTFOREM. These solutions may not fully address the criteria and boundary conditions, but will improve the U.S. Army's near-term capability to support the Future Combat System (FCS) program.

A second major technical area that SLAD is pursing is network M&S. Here, SLAD has adopted a strategy of flexible resolution for modeling the network architectures that will be at the heart of the Future Force. Some of SLAD's network modeling, conducted in partnership with the relevant system developers at Ft. Monmouth, NJ, is extremely high resolution. Inter- and intra-system protocols are explicitly modeled, routing is explicit, and message content is expressly portrayed at the bit/byte level. Other SLAD network modeling efforts are supporting the development of COMBAT XXI, the Army's next generation force-level tool for Analyses of Alternatives. (This model will replace CASTFOREM.) As a member of the COMBAT XXI development team, and in partnership with the TRADOC Analysis Center (TRAC), SLAD is designing and developing a network model that can propagate realistic information and electronic effects within COMBAT XXI. The network model will also operate in a stand-alone mode (outside of COMBAT XXI), which though it provides lower-resolution than engineering-level models, still offers a higher resolution than traditional force-level modeling and includes explicit modeling of the protocol architecture layers. In order to properly assess the needed level of network modeling, complex tradeoffs are required, and so much depends on precisely which transformation issue is under discussion. We believe that SLAD's strategy of flexibility with respect to network modeling resolution is prudent given today's uncertainties.

A related aspect of the SLAD strategy involves Active Protection Systems (APS). As part of the Army philosophy of trading mass for MIPS, APS plays a key role. In this area, the existing SLAD program focuses on the lethality and detection aspects of the problem. The long-term goal is to develop a technically robust tool that provides for the SLVAs of various APS designs that can be used against the full spectrum of battlefield threats.

The third major technical aspect of the SLAD strategy is the System-of-Systems Survivability Simulation (S4), an effort that has been ongoing for several years. The S4 embodies a collection of processes that revises strategies and behavior dynamically at all levels within the military hierarchy, and provides time-varying interactions of those processes with information that supports warfighting objectives. The model produces one process for every agent on the battlefield (i.e., a soldier, tank, sensor, or platoon) and then organizes them into multi-layer collectives. Each agent's revision process includes information and knowledge from local sensors, remote sensors via the network, its part engagements and encounters, and its general situational awareness/understanding. The S4 model, using agent technology, satisfies the necessary conditions for intellectual adequacy as argued for within this technical note.

SLAD's implementation strategy for the S4 principally focuses on keeping the (decision) agents, and their associated revision processes, at the core of the modeling effort (see fig 1). While sensing, maneuver, and engagement remain important, they are, by design, on the periphery of the S4 effort. This shift in emphasis helps us to direct program effort (which is often scarce) and ensures that we are leveraging TRAC's efforts in these areas to the maximum extent possible. As explained, communication/networking modeling is critical. The network model being developed

for COMBAT XXI will evolve to provide similar capability within the S4, thus satisfying the conditions stated previously.

Our long-term goal is to be able to support such events as FCS Milestone C. To do this, we must increase the sophistication of the agent revision processes to the point where the revisions to tactics, strategy, and previously made decisions are as subtle yet complex as such revisions actually are in the real world. For instance, Medal of Honor winner Alvin York did not set out to eliminate a troublesome machine gun nest, he revised his plan. We must capture more of this sort of phenomenon in our simulations if our analyses are to help senior leaders make the difficult decisions that lie ahead.

5.3   S4 and the Military Missions and Means Framework (MMF)

During the past several years, the S4 model and the Military Missions and Means Framework (MMF) were independently developed for quite separate purposes. Concurrent with an earlier published version of this technical note, a paper entitled "The Military Missions and Means Framework" was also published (*6*). This paper provided a framework for explicitly specifying the military mission and quantitatively evaluating the mission utility of alternative warfighting services and products relating to Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF). The overall objective of the MMF effort is to provide a framework to enable DoD decision makers, developers, and operators to clearly and unambiguously communicate throughout the range from planning concept to actual combat. We have found it encouraging that S4 fits so well with the MMF construction, which has garnered widespread support among Army and OSD decision makers.

In the S4 model each battlefield agent has a physical incarnation in addition to containing the decision-making processes that constitute the essence of the model. At the lowest level of complexity, each incarnation is essentially an individual entity (i.e., a soldier, a tank, a robotic gun, or a sensor). And just as entities of different types—even at the same layer—will usually have different decision-making processes so will they have different classes of physical interactions at **Level 1** of the MMF, different impact on the means to prosecute combat at **Level 2**, different impact on how well combat function/capabilities are performed at **Level 3**, and different task outcomes at **Level 4.**

Figure 1. S4 domain model.

6. Conclusions

At present, the revisions in tactics captured in S4 are at best reactive. While some combat outcomes can be characterized as based on situational awareness, we cannot yet capture enough of the higher-order processes involved in situational understanding. We can only crudely simulate battlefield plans in terms of first-order human factor variables. Much more sophistication is required before we have a model that gives intellectually satisfying answers to SLVA questions regarding adaptation and revision. SLAD is working with appropriate human factor experts and cognitive scientists to incorporate the appropriate variables into our S4 prototype modeling and simulation program. The key point is that the current and planned implementation models satisfy the necessary conditions argued for in this technical note.

7.   References

1. *Transformation Planning Guidance*; Apr 2003, Washington, DC.

2. Myers, G. Effects-Based Operations. *Armed Forces J.* **June 2003,** 47–49.

3. Hasslinger, K.; Gorman, P.; Jacobsohn, M.; Levy, M.; MacDonald, J.;O'Neil, A.; Webster, C. *Measuring the Effects of Network Centric Warfare, Exploring Belief Metrics in Warfare*; Information Assurance Technology Analysis Center: Falls Church, VA, May 14, 2002.

4. Deitz, P. H.; Starks, M. W.; Smith, J.; Ozolins, A. *Current Simulation Methods in Military Systems Vulnerability Assessment*; BRL MR-3880, Aberdeen Proving Ground, MD, Nov 1990.

5. Deitz, P. H.; Starks, M. W. The Generation, Use, and Misuse of 'PKs' in Vulnerability/Lethality Analyses. *Mil. Ops. Res.* **1999**, *4* (1).

6. Sheehan, J. H.; Deitz, P. H.; Bray, B. E.; Harris, B. A.; Wong, A. B. H. The Military Missions and Means Framework. *Proceedings from the Interservice/Industry Training, Simulation, and Education Conference,* 2003.

Acronyms

AFJ	Armed Forces Journal
APS	Active Protection Systems
CASTFOREM	Combined Arms Support Task Force Evaluation Model
DoD	Department of Defense
FCS	Future Combat System
IATAC	Information Assurance Technology Analysis Center
MIPs	millions of instructions per second
M&S	Modeling and Simulations
S4	Systems-of-Systems Survivability Simulation
SLAD	Survivability/Lethality Analysis Directorate
SLV	survivability/lethality/vulnerability
SLVA	survivability/lethality/vulnerability analysis
TRADOC	Training & Doctrine Command
TRAC	TRADOC Analysis Command

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